FORM PTO-1390 (REV 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		MTS-3286US U S APPLICATION NO (If known, see 37 CFR 1 5) 10/009671
INTERNATIONAL APPLICATION NO PCT/JP00/02968	INTERNATIONAL FILING DATE 10 May 2000 (10.05.00)	PRIORITY DATE CLAIMED 11 May 1999 (11.05.99)
TITLE OF INVENTION OPTICAL HEAD		
APPLICANT(S) FOR DO/EO/US Daisuke OGATA, Katuhiko YASUDA, Akihiro YASUDA		

Applicant herewith submits to the united States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern documents(s) or information included:

11. ☒ An Information Disclosure Statement under 37 U.S.C. 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 – 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☐ Other items or information:

U.S. APPLICATION NO (If known, see 37 CFR 1.5) 10/009671	INTERNATIONAL APPLICATION NO. PCT/JP00/02968	ATTORNEY DOCKET NUMBER MTS-3286US

21. ☒ The following fees are submitted.

BASIC NATIONAL FEE (37 CFR 1.492(a)(1) – (5)):

☐ Neither international preliminary examination fee (37 CFR 1 482) nor international search fee (37 CFR 1 445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO... .... **$1040.00**

☒ International preliminary examination fee (37 CFR 1 482)not paid to USPTO but International Search Report prepared by the EPO or JPO.... ..... **$890.00**

☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1 445(a)(2)) paid to USPTO **$740.00**

☐ International preliminary examination fee paid to USPTO (37 CFR 1 482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**

☐ International preliminary examination fee paid to USPTO (37 CFR 1 482) and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**

CALCULATIONS PTO USE ONLY	
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1 492(e)).	$

CLAIMS	NUMBER FILED	EXTRA NUMBER	RATE	
Total claims	7- 20 =	0	X $18 00	$
Independent claims	1 - 3 =	0	X $84 00	$
MULTIPLE DEPENDENT CLAIM(S) (if applicable)	☒		+ $280 00	$ 280 00
TOTAL OF ABOVE CALCULATIONS =				$ 1,170.00
☐ Applicant claims small entity status See 37 CFR 1.27 The fees indicated above are reduced by ½.				$
SUBTOTAL =				$
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 Months from the earliest claimed priority date (37 CFR 1 492(f)). +				$
TOTAL NATIONAL FEE =				$
Fee for recording the enclosed assignment (37 CFR 1 21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$
TOTAL FEES ENCLOSED =				$ 1,170.00
			Amount to be refunded:	$
			Charged:	$

a. ☒ A check in the amount of **$1170** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **18-0350**. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING**: Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:
Allan Ratner
Ratner & Prestia
P.O Box 980
Valley Forge, PA 19482
(610) 407-0700

SIGNATURE

Allan Ratner
NAME

19,717
REGISTRATION NUMBER

November 13, 2001
DATE

I:\MTS\3286us\pto-1390.doc

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	D. Ogata et al.	: Art Unit:
Serial No.:	To Be Assigned	: Examiner:
Filed:	Herewith	:
FOR:	OPTICAL HEAD	:

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231
S I R :

Prior to examination, please amend the above application as follows:

IN THE DRAWINGS:

Subject to approval by the Examiner in charge of the above-identified application please enter the correction to Figure 3 as shown in red.

IN THE SPECIFICATION:

After the title and before the first paragraph, please insert the following paragraph:

THIS APPLICATION IS A U.S. NATIONAL PHASE APPLICATION OF PCT INTERNATIONAL APPLICATION PCT/JP00/02968.

Specification at page 1, line 3:

The present invention relates to a (recording/reproduction) optical head for recording information on an information recording surface of an optical information recording medium or for reproducing information from the information recording surface by condensing a light flux emitted from a light source onto the information recording surface via a transparent substrate of the information recording medium.

Specification at page 6, line 10:

Here, in an optical head and an optical disc apparatus, the systems are usually designed to provide a permissible error in other tilt factors such as a manufacturing or assembly error or disc warp and there is the problem that in the case that a tilt difference occurs due to the skew adjustment in addition to the above, which becomes the size of approximately 0.3 degrees, the performance of the recording and reproduction of the CD is severely degraded.

Specification at page 10, line 5:

In Fig 1 a light flux emitted from a light source 11 of a wavelength of 650 nm becomes an approximately collimated by means of a condensing lens 13 via a beam splitter 12 so as to enter into an objective lens 14 and to focus an image as a light spot 17 on an information recording surface 16 of an optical disc 15.

Specification at page 11, line 4:

Though the light source 21 is conventionally placed at a position 31 of the light source so that the wave front aberration on the disc recording surface of a CD becomes of the minimum, it is installed on the side away from the objective lens 14 from the position 31 in the present invention.

Specification at page 11, line 10:

Concerning the objective lens 14, the skew adjustment is carried out the coma aberration of the light spot 17 of the DVD becomes essentially 0.

Specification at page 13, line 2:

The coma aberration, which changes in accordance with the objective lens skew, is the sum of the coma aberration due to the inclination of the central axis of the objective lens with respect to a line perpendicular to the disc and the coma aberration caused by the light source becoming shifted from the central axis of the objective lens. The former is referred to as a tilt coma aberration and the latter is referred to as an off-axis coma aberration. As is well known, the further the optical system is out of the sine conditions, the bigger the off-axis coma aberration becomes.

Specification at page 13, line 14:

In the case of the DVD, since the objective lens is designed so as to satisfy the sine condition, the off-axis coma aberration hardly occurs. Therefore, the skew adjustment is carried out where the objective lens is tilted so that a tilt coma aberration, of which the sign is opposite to that of the coma aberration that exists in the objective lens, occurs and, thereby, the coma aberration is cancelled. Contrarily, for the CD, in the case that the light source 21 is at the position 31 of the minimum wave front aberration, the sine condition is not satisfied and thereby the off-axis coma aberration occurs in addition to the tilt coma aberration. The off-axis coma aberration is of the opposite sign to the tilt coma aberration and is of the same sign as the coma aberration of the objective lens and, therefore, the amount of off-axis coma aberration with respect to the same skew angle is larger than that of the tilt coma aberration in absolute value so that a coma aberration that is larger than the coma aberration in the system for the CD of the objective lens remains even after the skew adjustment is carried out in the system for the DVD. Since the deviation from the sine condition for the CD is reduced as the light source

moves away from the position 31, the off-axis coma aberration due to the objective lens skew is also reduced. Therefore, the sum of the coma aberration of the objective lens at the time of skewing, the tilt coma aberration and the off-axis coma aberration is reduced in comparison with the case where the light source for the CD is at the position 31 so that the tilt difference is reduced.

Specification at page 15, line 11:

Judging from the above described principle of the occurrence of the tilt coma aberration and the off-axis coma aberration, it is assumed that there is a case where the absolute values of the tilt coma aberration and the off-axis coma aberration become equal, in relation to the same skew angle, when the light source for the CD is at a certain position since the farther away is the light source from the position 31, the more the off-axis coma aberration is reduced. At this time, the tilt coma aberration and the off-axis coma aberration always cancel each other regardless of the skew angle and, therefore, the sum of the coma aberrations does not change at all. In addition, in the case that the light source moves farther away beyond this position, the absolute value of the tilt coma aberration becomes larger than that of the off-axis coma aberration in relation to the same skew angle and, thereby, the amount of the remaining coma aberration must be reduced.

Specification at page 16, line 4:

The coma aberration for the CD is approximately 0.011 $\lambda 2$ when the skew angle of the objective lens 14 is 0 degrees in Fig 2, which is approximately equal to the coma aberration when the position of the light source 21 is approximately 2.9 mm away from the position 31 in Fig 3. At this time, the system is considered to be in the condition where the coma aberration

does not change, regardless of the skew angle. Considering this point, Embodiment 2 is gained by installing the light source 21 at a position farther away from this position than from the objective lens 1.

Specification at page 16, line 21:

In Fig 4, in the case that the distance of the light source 21 from the position 31 is approximately 2.9 mm, the coma aberration for the CD does not vary and is always constant, even in the case where the skew angle of the objective lens 14 changes. Hereinafter this is referred to as skew free.

Specification at page 17, line 2:

This means that the coma aberration and the tilt difference for the CD do not, essentially, increase when in the skew free condition even in the case that the skew adjustment is optimally carried out for the DVD. In the case of the skew free condition, the remaining coma aberration for the CD is constant at approximately 0.011 $\lambda 2$ and the resulting tilt difference is 0.16 degrees. In general, it is possible to configure an optical disc apparatus with a tilt difference of this extent. In addition, in the case that the light source 21 is on the side farther away from the objective lens 14 than from the skew free position, for example in the case that the distance of the light source 21 from the position 31 is approximately 5.7 mm, the coma aberration for the CD is reduced to 0.002 $\lambda 2$ as shown in Fig 4. The resultant tilt difference can almost be ignored.

Specification at page 18, line 4:

Secondly, it is advantageous from the viewpoint of the driving stroke of an actuator that drives the objective lens 14. When the light source

21 is placed at the position 31 of the minimum wave front aberration, the working distance of the objective lens 14 in the case that the CD is recorded or reproduced becomes approximately 0.2 mm shorter than that of the case of the DVD. Accordingly, the driving stroke of the actuator in focal distance is designed by taking the difference of these working distances into consideration.

Respectfully submitted,

Allan Rather, Reg. No. 19,717
Attorney for Applicants

AR/dlm
Enclosure: Version With Markings Showing Changes Made

Suite 301, One Westlakes, Berwyn
P.O. Box 980
Valley Forge, PA 19482-0980
(610) 407-0700

The Assistant Commissioner for Patents is hereby authorized to charge payment to Deposit Account No. **18-0350** of any fees associated with this communication.

EXPRESS MAIL Mailing Label Number: EL 923263923US
Date of Deposit: November 13, 2001

I hereby certify that this paper and fee are being deposited, under 37 C.F.R. § 1.10 and with sufficient postage, using the "Express Mail Post Office to Addressee" service of the United States Postal Service on the date indicated above and that the deposit is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

Kathleen Libby
Kathleen Libby

VERSION WITH MARKINGS SHOWING CHANGES MADE

DRAWINGS:

Subject to approval by the Examiner in charge of the above-identified application please enter the correction to Figure 3 as shown in red.

IN THE SPECIFICATION:

After the title and before the first paragraph:

THIS APPLICATION IS A U.S. NATIONAL PHASE APPLICATION OF PCT INTERNATIONAL APPLICATION PCT/JP00/002968.

Specification at page 1, line 3:

The present invention relates to a (recording/reproduction) optical head ~~in a condensing optical system~~ for recording information on an information recording surface of an optical information recording medium or for reproducing information from the information recording surface by condensing a light flux emitted from a light source onto the information recording surface via a transparent substrate of the information recording medium.

Specification at page 6, line 10:

Here, in an optical head and an optical disc apparatus, the systems are usually designed to provide a permissible error in other tilt factors such as a manufacturing or assembly error or disc warp and there is the

problem that in the case that a tilt difference occurs due to the skew adjustment in addition to the above, which becomes the size of approximately 0.3 degrees, ~~the configuration of the optical disc apparatus becomes difficult with respect to the recording and reproduction of the Cd~~the performance of the recording and reproduction of the CD is severely degraded.

Specification at page 10, line 5:

In Fig 1 a light flux emitted from a light source 11 of a wavelength of 650 nm becomes an approximately ~~parallel light flux~~ collimated by means of a condensing lens 13 via a beam splitter 12 so as to enter into an objective lens 14 and to focus an image as a light spot 17 on an information recording surface 16 of an optical disc 15.

Specification at page 11, line 4:

Though the light source 21 is conventionally placed at a position 31 of the light source so that the wave front aberration on the disc recording surface of a CD becomes of the minimum, it is installed on the side away from the objective lens ~~15~~14 from the position 31 in the present invention.

Specification at page 11, line 10:

Concerning the objective lens ~~15~~ 14, the skew adjustment is carried out the coma aberration of the light spot 17 of the DVD becomes essentially 0.

Specification at page 13, line 2:

~~The principle herein is described.~~ The coma aberration, which changes in accordance with the objective lens skew, is the sum of the coma

aberration due to the inclination of the central axis of the objective lens with respect to a line perpendicular to the disc and the coma aberration caused by the light source becoming shifted from the central axis of the objective lens~~, from the viewpoint of the objective lens~~. The former is referred to as a tilt coma aberration and the latter is referred to as an off-axis coma aberration. As is well known, the further the optical system is out of the sine conditions, the bigger the off-axis coma aberration becomes.

Specification at page 13, line 14:

In the case of the DVD, since the objective lens is designed so as to satisfy the sine condition, the off-axis coma aberration hardly occurs. Therefore, the skew adjustment is carried out where the objective lens is tilted so that a tilt coma aberration, of which the sign is opposite to that of the coma aberration that exists in the objective lens, occurs and, thereby, the coma aberration is cancelled. Contrarily, for the CD, in the case that the light source 21 is at the position 31 of the minimum wave front aberration, the sine condition is not satisfied and thereby the off-axis coma aberration occurs in addition to the tilt coma aberration. The off-axis coma aberration is of the opposite sign to the tilt coma aberration and is of the same sign as the coma aberration of the objective lens and, therefore, the amount of off-axis coma aberration with respect to the same skew angle is larger than that of the tilt coma aberration in absolute value so that a coma aberration that is larger than the coma aberration in the system for the CD of the objective lens remains even after the skew adjustment is carried out in the system for the DVD. Since the deviation from the sine condition for the CD is reduced as the light source moves away from the position 31, the off-axis coma aberration due to the objective lens skew is also reduced. Therefore, the sum of the coma aberration

of the objective lens at the time of skewing, the tilt coma aberration and the off-axis coma aberration is reduced in comparison with the case where the light source for the CD is at the position 31 so that the tilt ~~residual~~ difference is reduced.

Specification at page 15, line 11:

Judging from the above described principle of the occurrence of the tilt coma aberration and the off-axis coma aberration, it is assumed that there is a case where the absolute values of the tilt coma aberration and the off-axis coma aberration become equal, in relation to the same skew angle, when the light source for the CD is at a certain position since the farther away is the light source from the position 31, the more the off-axis coma aberration is reduced. At this time, the tilt coma aberration and the off-axis coma aberration always cancel each other regardless of ~~the size of~~ the skew angle and, therefore, the sum of the coma aberrations does not change at all. In addition, in the case that the light source moves farther away beyond this position, the absolute value of the tilt coma aberration becomes larger than that of the off-axis coma aberration in relation to the same skew angle and, thereby, the amount of the remaining coma aberration must be reduced.

Specification at page 16, line 4:

The coma aberration for the CD is approximately 0.011 $\lambda 2$ when the skew angle of the objective lens ~~15~~ 14 is 0 degrees in Fig 2, which is approximately equal to the coma aberration when the position of the light source 21 is approximately 2.9 mm away from the position 31 in Fig 3. At this time, the system is considered to be in the condition where the coma aberration does not change, regardless of the skew angle. Considering this point,

Embodiment 2 is gained by installing the light source 21 at a position farther away from this position than from the objective lens 1.

Specification at page 16, line 21:

In Fig 4, in the case that the distance of the light source 21 from the position 31 is approximately 2.9 mm, the coma aberration for the CD does not vary and is always constant, even in the case where the skew angle of the objective lens ~~15~~ 14 changes. Hereinafter this is referred to as skew free.

Specification at page 17, line 2:

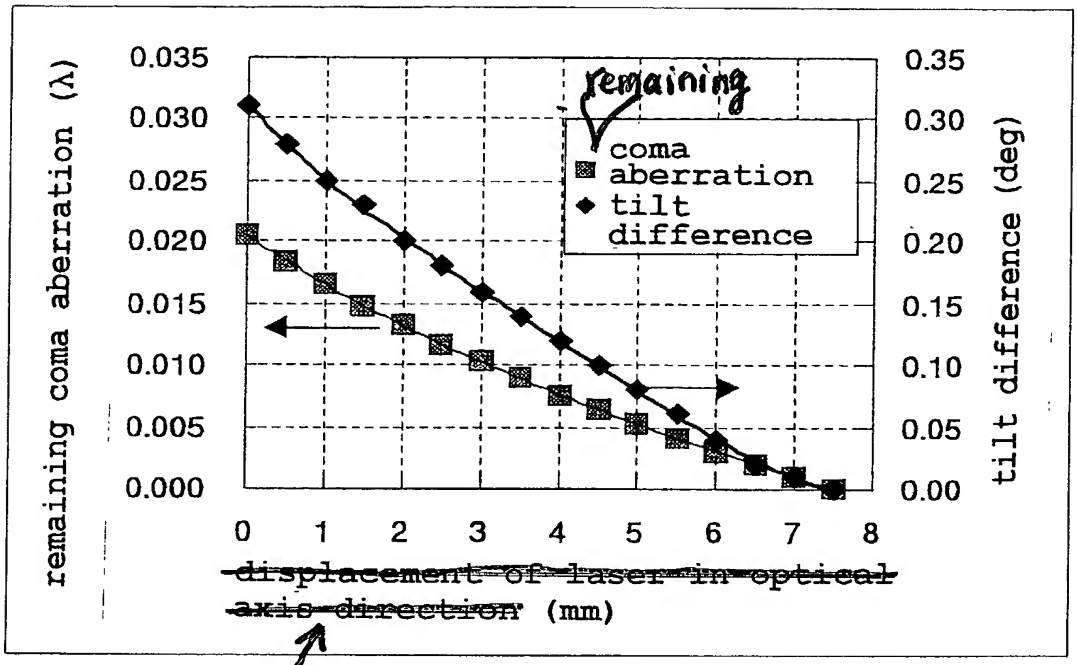
This means that the coma aberration and the tilt difference for the CD do not, essentially, increase when in the skew free condition even in the case that the skew adjustment is optimally carried out for the DVD. In the case of the skew free condition, the remaining coma aberration for the CD is constant at approximately 0.011 $\lambda 2$ and the resulting tilt difference is 0.16 degrees. In general, it is possible to configure an optical disc apparatus with a tilt difference of this extent. In addition, in the case that the light source 21 is on the side farther away from the objective lens ~~15~~ 14 than from the skew free position, for example in the case that the distance of the light source 21 from the position 31 is approximately 5.7 mm, the coma aberration for the CD is reduced to 0.002 $\lambda 2$ as shown in Fig 4. The resultant tilt difference can almost be ignored.

Specification at page 18, line 4:

Secondly, it is advantageous from the viewpoint of the driving stroke of an actuator that drives the objective lens ~~15~~14. When the light source 21 is placed at the position 31 of the minimum wave front aberration, the

working distance of the objective lens ~~15~~ 14 in the case that the CD is recorded or reproduced becomes approximately 0.2 mm shorter than that of the case of the DVD. Accordingly, the driving stroke of the actuator in focal distance is designed by taking the difference of these working distances into consideration.

Fig. 3



displacement of light source from the position of the minimum wave front aberration in optical axis direction

MTS-3286US PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	D. Ogata et al.	: Art Unit:
Serial No.:	10/009,671	: Examiner:
Filed:	Herewith	:
FOR:	OPTICAL HEAD	:

SUPPLEMENTAL PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231
S I R :

Prior to examination, please further amend the above application as follows:

IN THE CLAIMS:

6. (Newly Added) A method of converging a light flux emitted from a light source onto an information recording surface of an optical information recording medium, the method comprising the steps of:

(a) converging, in a first light path, a light flux from a first light source onto a first optical information recording medium, in which the first light path includes an objective lens;

(b) converging, in a second light path, a light flux from a second light source onto a second optical information recording medium, in which the second light path includes the same objective lens as the first light path;

(c) adjusting a skew angle of the objective lens to obtain a value of substantially 0 coma aberration in the first optical information medium;

(d) configuring the second light path as a finite conjugating optical path;

(e) determining a predetermined position of the second light source in the

second light path to obtain a minimum rms value of wavefront aberration in the second optical information recording medium; and

(f) positioning the second light source in the second light path, at a position further away from the objective lens than the predetermined position.

7. (Newly Added) The method of claim 6 wherein step (f) includes positioning the second light source at a position between the predetermined position and a position in which the second light path becomes an infinite conjugating optical path.

Respectfully submitted,

Allan Ratner, Reg. No. 19,717
Attorney for Applicants

AR/lm
Date: June 26, 2002
Enclosure: Version With Markings Showing Changes Made

Suite 301, One Westlakes, Berwyn
P.O. Box 980
Valley Forge, PA 19482-0980
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The Assistant Commissioner for Patents is hereby authorized to charge payment to Deposit Account No. **18-0350** of any fees associated with this communication.

EXPRESS MAIL Mailing Label Number: EV050915253US
Date of Deposit: June 26, 2002

I hereby certify that this paper and fee are being deposited, under 37 C.F.R. § 1.10 and with sufficient postage, using the "Express Mail Post Office to Addressee" service of the United States Postal Service on the date indicated above and that the deposit is addressed to the Assistant Commissioner for Patents, Washington, D C. 20231

Kathleen Libby

VERSION WITH MARKINGS SHOWING CHANGES MADE

CLAIMS:

Claims 6 and 7 are newly added.

5/pats

Specification

Optical Head

Technical Field

The present invention relates to a (recording/reproduction) optical head in a condensing optical system for recording information on an information recording surface of an optical information recording medium or for reproducing information from the information recording surface by condensing a light flux emitted from a light source onto the information recording surface via a transparent substrate of the information recording medium.

Background Technology

In recent years because of increases in recording density and in usage of recordable media, the standards of optical discs have increased so that it has become necessary to change the numerical aperture (hereinafter referred to simply as NA) of objective lenses or the wavelength utilized in an optical system for recording and/or reproduction (hereinafter referred to simply as an optical system) in order to correspond to the difference of the thickness of the disc substrate or to the wavelength dependency of the reflectance.

For example, the thickness of the CD substrate is 1.2 mm while that of the DVD is 0.6 mm. In addition, as for the reflectance of the disc recording material utilized in the CD-R is 65%, or more, for the wavelength of 780 nm to 830 nm while it drops to 20%, or less, for the wavelength of 635 nm to 650 nm.

Accordingly, in general, in the optical system for DVD, a light source wavelength of 635 nm to 650 nm and an NA of 0.6 of the objective lens are utilized while in the optical system for the CD-R, a light source wavelength of 780 nm to 830 nm and an NA of 0.45 of the objective lens are utilized.

Therefore, it is desirable for optical discs of which the corresponding optical systems differ in such a manner to be able to record or reproduce with the same optical disc apparatus and, at the same time, it is required for the optical disc apparatus to be miniaturized and to be reduced in cost. That is to say, a system is proposed where as many parts as possible are used in common for optical systems corresponding to optical discs of differing standards.

As an exemplary system thereof, there is the optical head as shown in the Japanese unexamined patent publication H8(1996)-55363. In this optical head the condensing lens for condensing a light flux emitted from the light source

and the objective lens for conversion of the light flux onto the information recording surface of an optical disc are, respectively, used in common.

That is to say, the optical system corresponding to a high density optical disc, such as a DVD, is made to be an infinitely conjugating system (hereinafter referred to simply as infinite system) using a light source of the wavelength of 650 nm while the objective lens thereof is optimally designed for the thickness of the high density optical disc substrate in the infinite system.

In the case that an optical disc of a comparatively low density having a different substrate thickness in comparison with a DVD, such as a CD or a CD-R, is recorded or reproduced, the optical system is made to be a finitely conjugating system (hereinafter referred to as a finite system) using a light source of the wavelength of 780 nm wherein an excellent signal recording and reproduction characteristic can be gained by canceling the spherical aberration caused by differences in the thickness of the substrate.

Here, an aberration due to an error in manufacturing or assembly usually exists in an optical system. Third order aberrations such as coma aberration, astigmatism and spherical aberration mainly affect the recording and reproduction of information to the greatest degree and,

in general, a skew adjustment where the angle of the optical axis of the objective lens is varied is carried out in order to correct the coma aberration from among the above.

The shorter the wavelength is the smaller the amounts of these aberrations need to be and, in general, the higher the recording density of an optical disc is the shorter the wavelength used becomes. Accordingly, in an optical head that carries out recording and reproduction of optical discs, of which the thickness of the substrates or the recording densities differ, by using a plurality of light sources, the skew angle of the objective lens must be adjusted for an optical disc of which the density is relatively high. In this case, it becomes a problem in that these aberrations do not necessarily allow optimal conditions for recording and reproduction of an optical disc of which the density is relatively low.

This situation is described in reference to Fig 5. Fig 5 shows an optical system wherein a DVD (substrate thickness of 0.6 mm) is assumed as a high density optical information recording medium and a CD (substrate thickness of 1.2 mm) is assumed as low density optical information recording medium. That is to say, the relationships between the skew angle and the coma aberration on the recording surface of the DVD disc and of the CD disc are shown in the case where a coma aberration exists in the objective

lens.

Here, the vertical axis indicates the rms value of the aberration normalized with the light source wavelength and the rms value of the coma aberration which exists in the objective lens is 0.035 $\lambda 1$ ($\lambda 1$ is the light source wavelength corresponding to the DVD). This is a value that can occur as an aberration due to a manufacturing error. All of the values of the aberrations are described as rms values in the following.

In the case that the objective lens does not tilt relative to the optical axis, that is to say, in the case that the skew angle is 0 degrees, the coma aberration on the disc recording surface of the DVD is equal to the coma aberration of the objective lens. This is shown by dot A in Fig 5.

When the skew angle of the objective lens is changed from this condition, the coma aberration can be reduced to approximately 0. The skew angle of the objective lens at this time is approximately 0.33 degrees. This is shown by dot B in Fig 5.

Contrarily, the value of the coma aberration of the CD is 0.011 $\lambda 2$ ($\lambda 2$ is a light source wavelength corresponding to the CD) before the skew adjustment while it increases to 0.021 $\lambda 2$ after the skew adjustment. This is shown as the increase from dot A' to dot B' in Fig 5

and it can be seen that the increase and the reduction in the coma aberration are opposite for the DVD and for the CD with respect to the skew angle of the objective lens.

The value 0.021 $\lambda 2$ of the coma aberration of the CD after the skew adjustment corresponds to the tilt angle of 0.3 degrees of the disc. Accordingly, a difference of 0.3 degrees occurs in the disc tilt angle, between the DVD and the CD, wherein the jitter becomes of the minimum. This difference is hereinafter referred to as a tilt difference.

Here, in an optical head and an optical disc apparatus, the systems are usually designed to provide a permissible error in other tilt factors such as a manufacturing or assembly error or disc warp and there is the problem that in the case that a tilt difference occurs due to the skew adjustment in addition to the above, which becomes the size of approximately 0.3 degrees, the configuration of the optical disc apparatus becomes difficult with respect to the recording and reproduction of the CD.

Disclosure of the Invention

Considering the problem of the above described optical head according to the prior art, the object of the present invention is to provide an optical head which optimally adjusts the skew angle of the objective lens relative to the high density optical information recording medium and,

at the same time, can reduce the tilt difference between the optical system used for the relatively low density optical information recording medium, which is greater in substrate thickness, and that used for the high density optical information recording medium.

The present application is an optical head for converging a light flux emitted from a light source onto an information recording surface of an optical information recording medium via a transparent substrate of the medium and, thereby, recording information on said information recording surface or reproducing information from said information recording surface, the optical head comprising:

a first light path for converging a light flux from a first light source of which the wavelength is $\lambda 1$ onto a first optical information recording medium of which the substrate thickness is t1: and a second light path for converging a light flux from a second light source of which the wavelength is $\lambda 2$ (where $\lambda 1 < \lambda 2$) onto a second optical disc of which the substrate thickness is t2 (where t1 < t2), wherein

said first and second light paths share the same objective lens,

a skew adjustment is carried out on said objective lens so that the coma aberration of said first optical

information recording medium becomes essentially 0,

said second light path is configured as a finite conjugating system, and

the position of said second light source in the optical axis direction is set on the side that is farther away from said objective lens than from the predetermined position where the rms value of the wave front aberration on the information recording surface of said second optical information recording medium becomes of the minimum.

Brief Description of the Drawings

Fig 1 is a configuration diagram of an optical system according to the first embodiment of the present invention;

Fig 2 is a graph showing the relationships between the skew angle of the objective lens and the coma aberration according to the first embodiment of the present invention;

Fig 3 is a graph showing the relationships between the position in the direction of the optical axis of the light source and the coma aberration as well as the tilt difference at the time of skew adjustment according to the first embodiment of the present invention;

Fig 4 is a graph showing the relationships between the skew angle of the objective lens and the coma aberration according to the second embodiment of the present invention; and

Fig 5 is a graph showing the skew angle of the objective lens and the coma aberration in an optical system according to a prior art.

(Description of the Numerals)

11 first light source

12 beam splitter

13 condensing lens

14 objective lens

15 first optical disc

16 information recording surface of first optical disc

17 first light spot

21 second light source

24 aperture limitation means

25 second optical disc

26 information recording surface of second optical disc

27 second light spot

Best Mode for Carrying Out the Invention

In the following, the embodiments of the present invention are described in reference to Figs 1 to 4.

(Embodiment 1)

Fig 1 shows a configuration of an optical head wherein a DVD (substrate thickness of 0.6 mm) is assumed as a high density optical information recording medium and a CD (substrate thickness of 1.2 mm) is assumed as a low density

optical information recording medium. Here, for the purposes of simplicity, the description concerning the detection optical system for detecting light reflected from the disc is omitted.

In Fig 1 a light flux emitted from a light source 11 of a wavelength of 650 nm becomes an approximately parallel light flux by means of a condensing lens 13 via a beam splitter 12 so as to enter into an objective lens 14 and to focus an image as a light spot 17 on an information recording surface 16 of an optical disc 15.

At this time, the NA on the side of the optical disc 15 is 0.6 and the objective lens 14 is designed so that the best performance can be gained with respect to this optical system. For example, it is designed so that the wave front aberration becomes essentially 0.

In addition, a light flux emitted from a light source 21 of a wavelength of 780 nm becomes divergent light by means of the condensing lens 12 and enters the objective lens 14 after being narrowed into an appropriate diameter of light flux by an aperture limitation means 24 via the beam splitter 13 so as to focus an image as a light spot 27 on an information recording surface 26 of an optical disc 25.

At this time, the NA on the side of the optical disc 25 is 0.45 and the aperture limitation means 24, which is

configured of an appropriate means, carries out a narrowing function only on the light flux from the light source 21 while not affecting a light flux from the light source 11.

Though the light source 21 is conventionally placed at a position 31 of the light source so that the wave front aberration on the disc recording surface of a CD becomes of the minimum, it is installed on the side away from the objective lens 15 from the position 31 in the present invention.

Concerning the objective lens 15, the skew adjustment is carried out the coma aberration of the light spot 17 of the DVD becomes essentially 0.

The operation of the optical head configured in the above manner is described in the following.

Fig 2 is a graph showing the relationships between the lens skew angle and the coma aberrations on the recording surface of the DVD as well as on the recording surface of the CD in the case that the coma aberrations exist in the objective lens of the optical system of Fig 1. Here, the vertical axis indicates the value of the aberration normalized by the light source wavelength wherein the coma aberration that exists in the objective lens is 0.035 λ 1. This is the value which may occur as an aberration due to a manufacturing error. In addition, the coma aberration of the case where the light source 21 is at the position

31 is also shown.

In Fig 2, in the case that the skew angle of the objective lens is 0 degrees, though the coma aberration of the CD becomes 0.011 λ2 in the same manner as the case of a prior art, the degree of the change of the coma aberration with respect to the skew angle is smaller than that of the case where the light source 21 is at the position 31 so that the slope of the graph becomes smaller.

Then, in the case that the skew adjustment is carried out so that the coma aberration of the DVD becomes 0, the coma aberration of the CD is 0.016 λ2. Though this value has become larger than the value before the skew adjustment, it has become smaller than the value 0.021 λ2 of the case where the light source 21 is placed at the position 31, that is to say, the case of the prior art and the disc tilt for canceling this is 0.24 degrees in comparison with 0.31 degrees of the prior art.

This means that the tilt difference between the DVD and the CD has been reduced in comparison with that of the prior art.

In this manner, it can be seen that the tilt difference caused by the objective lens skew is reduced when the light source 21 is moved from the wave front aberration minimum position 31 to the side away from the objective lens in the optical system for the CD.

This is theoretically analyzed as follows.

The principle herein is described. The coma aberration, which changes in accordance with the objective lens skew, is the sum of the coma aberration due to the inclination of the central axis of the objective lens with respect to a line perpendicular to the disc and the coma aberration caused by the light source becoming shifted from the central axis of the objective lens, from the viewpoint of the objective lens. The former is referred to as a tilt coma aberration and the latter is referred to as an off-axis coma aberration. As is well known, the further the optical system is out of the sine conditions, the bigger the off-axis coma aberration becomes.

In the case of the DVD, since the objective lens is designed so as to satisfy the sine condition, the off-axis coma aberration hardly occurs. Therefore, the skew adjustment is carried out where the objective lens is tilted so that a tilt coma aberration, of which the sign is opposite to that of the coma aberration that exists in the objective lens, occurs and, thereby, the coma aberration is cancelled. Contrarily, for the CD, in the case that the light source 21 is at the position 31 of the minimum wave front aberration, the sine condition is not satisfied and thereby the off-axis coma aberration occurs in addition to the tilt coma aberration. The off-axis coma aberration is of the opposite

sign to the tilt coma aberration and is of the same sign as the coma aberration of the objective lens and, therefore, the amount of off-axis coma aberration with respect to the same skew angle is larger than that of the tilt coma aberration in absolute value so that a coma aberration that is larger than the coma aberration in the system for the CD of the objective lens remains even after the skew adjustment is carried out in the system for the DVD. Since the deviation from the sine condition for the CD is reduced as the light source moves away from the position 31, the off-axis coma aberration due to the objective lens skew is also reduced. Therefore, the sum of the coma aberration of the objective lens at the time of skewing, the tilt coma aberration and the off-axis coma aberration is reduced in comparison with the case where the light source for the CD is at the position 31 so that the tilt residual is reduced.

Fig 3 is a graph showing the relationships between the displacement amount of the light source 21 from the position 31 and the remaining coma aberration of the CD after the skew adjustment as well as the resulting tilt difference in the optical system of Fig 1. Here, the focal distance of the objective lens 14 is 3.3 mm, the focal distance of the condensing lens 13 is 20 mm and the NA of the optical disc 26 side is always kept at 0.45 by varying the aperture diameter of the aperture limitation means 24

in accordance with the position of the light source 21.

It can be seen from Fig 3 that the farther away is the light source 21 from the position 31, the more the remaining coma aberration and the tilt difference are reduced. Accordingly, the tilt difference can be controlled at the value that can be tolerated, or less, in the configuration of the optical disc apparatus by appropriately selecting the position of the light source 21 in the optical access direction.

(Embodiment 2)

Judging from the above described principle of the occurrence of the tilt coma aberration and the off-axis coma aberration, it is assumed that there is a case where the absolute values of the tilt coma aberration and the off-axis coma aberration become equal, in relation to the same skew angle, when the light source for the CD is at a certain position since the farther away is the light source from the position 31, the more the off-axis coma aberration is reduced. At this time, the tilt coma aberration and the off-axis coma aberration always cancel each other regardless of the size of the skew angle and, therefore, the sum of the coma aberrations does not change at all. In addition, in the case that the light source moves farther away beyond this position, the absolute value of the tilt coma aberration becomes larger than that of the off-axis

coma aberration in relation to the same skew angle and, thereby, the amount of the remaining coma aberration must be reduced.

The coma aberration for the CD is approximately 0.011 λ2 when the skew angle of the objective lens 15 is 0 degrees in Fig 2, which is approximately equal to the coma aberration when the position of the light source 21 is approximately 2.9 mm away from the position 31 in Fig 3. At this time, the system is considered to be in the condition where the coma aberration does not change, regardless of the skew angle. Considering this point, Embodiment 2 is gained by installing the light source 21 at a position farther away from this position than from the objective lens 1.

The operation of the optical head of this case is described in the following.

Fig 4 is a graph showing the relationships between the lens skew angle and the coma aberrations on the recording surfaces of the DVD and the CD in the case where the position of the light source 21 is 2.9 mm as well as 5.7 mm away from the position 31.

In Fig 4, in the case that the distance of the light source 21 from the position 31 is approximately 2.9 mm, the coma aberration for the CD does not vary and is always constant, even in the case where the skew angle of the objective lens 15 changes. Hereinafter this is referred

to as skew free.

This means that the coma aberration and the tilt difference for the CD do not, essentially, increase when in the skew free condition even in the case that the skew adjustment is optimally carried out for the DVD. In the case of the skew free condition, the remaining coma aberration for the CD is constant at approximately 0.011 λ2 and the resulting tilt difference is 0.16 degrees. In general, it is possible to configure an optical disc apparatus with a tilt difference of this extent. In addition, in the case that the light source 21 is on the side farther away from the objective lens 15 than from the skew free position, for example in the case that the distance of the light source 21 from the position 31 is approximately 5.7 mm, the coma aberration for the CD is reduced to 0.002 λ as shown in Fig 4. The resultant tilt difference can almost be ignored.

Here, though in the case that the position of the light source 21 is made to be on the side farther away from the skew free position a configuration with less tilt difference can be gained, placing the light source 21 at the skew free position has the following advantages.

Firstly, the optical head can be made compact. It is clear that the farther away is the position of the light source 21, the larger the dimensions of the optical head

become. Contrarily, the skew free position provides the arrangement where the optical head can be made most compact within the range where the tilt difference can be tolerated.

Secondly, it is advantageous from the viewpoint of the driving stroke of an actuator that drives the objective lens 15. When the light source 21 is placed at the position 31 of the minimum wave front aberration, the working distance of the objective lens 15 in the case that the CD is recorded or reproduced becomes approximately 0.2 mm shorter than that of the case of the DVD. Accordingly, the driving stroke of the actuator in focal distance is designed by taking the difference of these working distances into consideration.

On the other hand, in the case that the light source 21 is placed at the position where the optical system for the CD becomes an infinite system, the working distance for the CD becomes 0.35 mm to 0.4 mm shorter than that for the DVD and further expansion of the driving stroke of the actuator is necessary.

Contrarily, in the case of the skew free position, the difference of the working distances between the CD and the DVD is approximately 0.28 mm and it is not necessary to expand the driving stroke as in the case of an infinite system. In particular, in the case where it is strongly required to make the optical head thinner, such as in an

optical disc apparatus for being built in a laptop personal computer or for portable applications, it is difficult to expand the driving stroke in the focal direction where the difference of the working distances is desired to be as small as possible and, therefore, there is the great advantage in the skew free arrangement for such applications.

Here, though the position of the light source 21 is described as the skew free position in the present embodiment, a small shift of the light source from this position does not cause a great change in the relationships between the skew angle and the coma aberration on the one hand, as well as the tilt difference on the other and, therefore, a small change in the position of the light source within the tolerance of the tilt difference due to the conditions of optical head design constraints is, of course, acceptable.

As described above, according to the present invention since the light source 21 is placed away from the position 31 where the wave front aberration becomes of the minimum, the spherical aberration increases. For example, in the optical system shown in this embodiment, when the distance of the light source 21 from the position 31 is 5.7 mm, an infinite system is provided. Though the remaining coma aberration after the skew adjustment of this case is as small as 0.005 λ2 and the resultant tilt difference becomes

0.05 degrees, which is an amount that can also be ignored, the spherical aberration becomes 0.15 $\lambda 2$, which greatly exceeds the Marechal's criterion 0.07 $\lambda 2$ that is usually used as a benchmark. In such a case a variety of methods are purposed in order to carry out good recording and reproduction of the CD. For example, there is the method as shown in the Japanese unexamined patent publication H10(1998)-208281. This makes a good recording and reproduction possible while an infinite optical system is provided for both the DVD and the CD by correcting the aberration of the central part of the objective lens for the DVD so that a light spot of the minimum aberration is formed on the optical disc of which the substrate thickness is 0.84 mm to 1.2 mm. The usage of such a method does not cause a problem even in the case that the spherical aberration increases by placing the light source 21 farther away than the position 31.

In addition, though the first optical information recording medium according to the present invention is the DVD in the above described embodiment and the second optical information recording medium is the CD in the above described embodiment, the present invention is not limited these but, rather, may be combinations of DVD and PD or DVD and LD (laser disc) and, in conclusion, the present invention is applicable to two types of optical information recording

media which are in the relationship where the thickness of the substrate is relatively less and the recording density is higher.

Industrial Applicability

As described above, according to the present invention, concerning an optical head that has a plurality of light sources of differing wavelengths and that corresponds to optical information recording media of differing substrate thickness and of differing recording densities,

it becomes possible to gain an optical head that can control, within the tolerance, the tilt difference due to the coma aberration caused on the recording surface of the optical information recording medium of a relatively low density in the case that a skew adjustment is optimally carried out on the objective lens for the optical information recording medium of a relatively high density.

In addition, the present invention makes it possible to provide an optical system that is advantageous for making the optical head more compact, or thinner, by limiting to the minimum the increase of the dimensions of the optical system while controlling the tilt difference and by limiting to the minimum the increase of the difference in working distance of the objective lens with respect to a high density optical information recording medium and to a low density

optical information recording medium.

Claims

1. An optical head for converging a light flux emitted from a light source onto an information recording surface of an optical information recording medium via a transparent substrate of the medium and, thereby, recording information on said information recording surface or reproducing information from said information recording surface, the optical head comprising:

a first light path for converging a light flux from a first light source of which the wavelength is $\lambda 1$ onto a first optical information recording medium of which the substrate thickness is t1: and a second light path for converging a light flux from a second light source of which the wavelength is $\lambda 2$ (where $\lambda 1 < \lambda 2$) onto a second optical disc of which the substrate thickness is t2 (where t1 < t2), wherein

said first and second light paths share the same objective lens,

a skew adjustment is carried out on said objective lens so that the coma aberration of said first optical information recording medium becomes essentially 0,

said second light path is configured as a finite conjugating system, and

the position of said second light source in the optical axis direction is set on the side that is farther away from

said objective lens than from the predetermined position where the rms value of the wave front aberration on the information recording surface of said second optical information recording medium becomes of the minimum.

2. An optical head according to Claim 1, characterized in that the position of said second light source in the optical axis direction is set between said predetermined position and the position where said second light path becomes an infinite system.

3. An optical head according to Claim 1 or 2, characterized in that the position of said second light source in the optical axis direction is set at a position where the rms value of the coma aberration of said second light path does not change, even in the case that the skew angle of said objective lens changes.

4. An optical head according to Claim 1, characterized in that said wavelengths $\lambda 1$ and $\lambda 2$ and said substrate thickness t1 and t2 are, respectively, as follows:

$620\ nm < \lambda 1 < 680\ nm$

$740\ nm < \lambda 2 < 820\ nm$

$0.4\ mm < t1 < 0.8\ mm$

$1.0\ mm < t2 < 1.5\ mm$.

5. An optical head according to Claim 1 or 2, characterized in that said first optical information recording medium is a DVD, said wavelength $\lambda 1$ is 650 nm,

said second optical information recording medium is a CD and said wavelength $\lambda 2$ is 780 nm.

Abstract

In an optical system wherein optical systems corresponding to optical discs of differing standards are combined by sharing some parts, in the case that a skew adjustment is optimally carried out on the objective lens for one medium, the difference in the best tilt angle due to the coma aberration occurring for the other medium is reduced.

The position of the second light source in the optical axis direction is set on the side that is farther away from the objective lens than from the position where the wave front aberration becomes of the minimum. Thereby, the amount of increase of the coma aberration is reduced when the skew angle of the objective lens changes in accordance with the second optical information recording medium. In addition, more preferably, the light source is set at the position where the coma aberration does not change in accordance with the skew angle of the objective lens. This position is located between the position where the wave front aberration is of the minimum and the position where the optical system becomes an infinite system so that the increase of the dimensions of the optical head can be controlled and the increase of difference of the working distances can be controlled in accordance with the two optical information recording media.

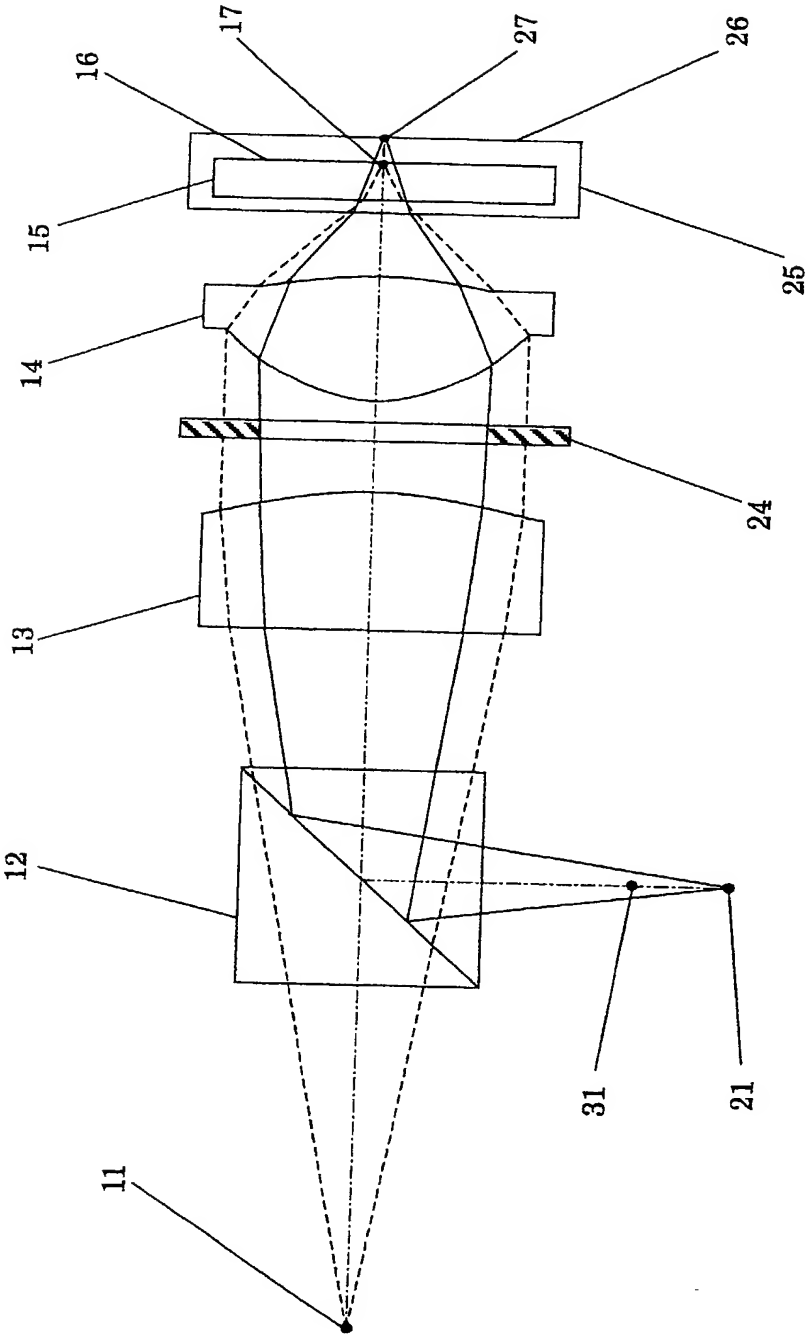


Fig. 1

Fig. 2

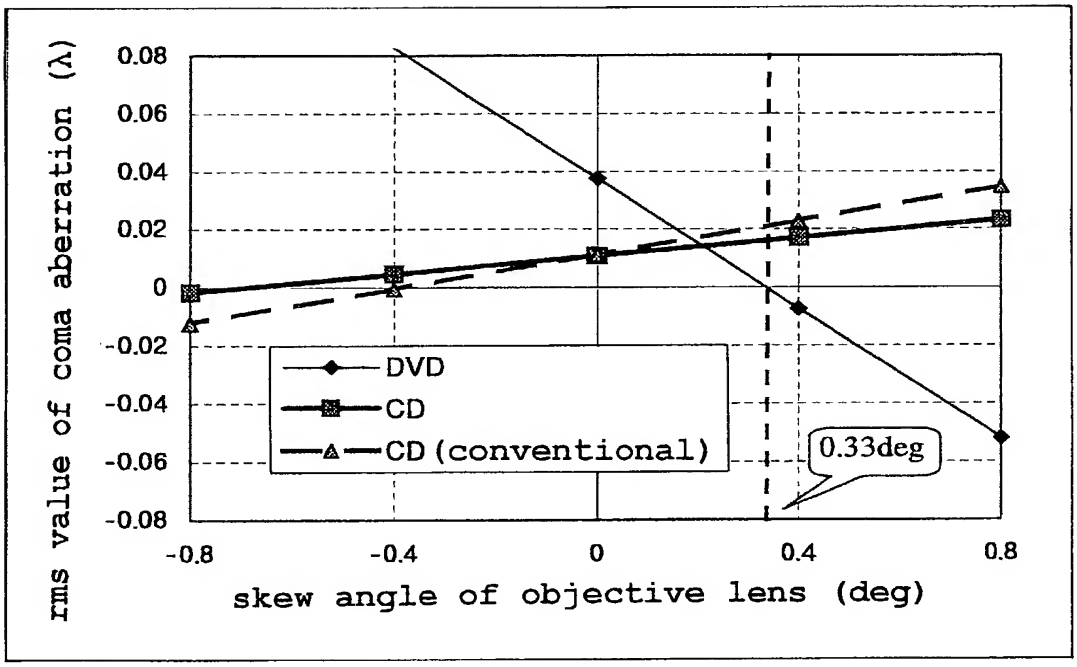

rms value of coma aberration (λ)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.8
-0.4
0
0.4
0.8
skew angle of objective lens (deg)
DVD
CD
CD (conventional)
0.33deg

Fig. 3

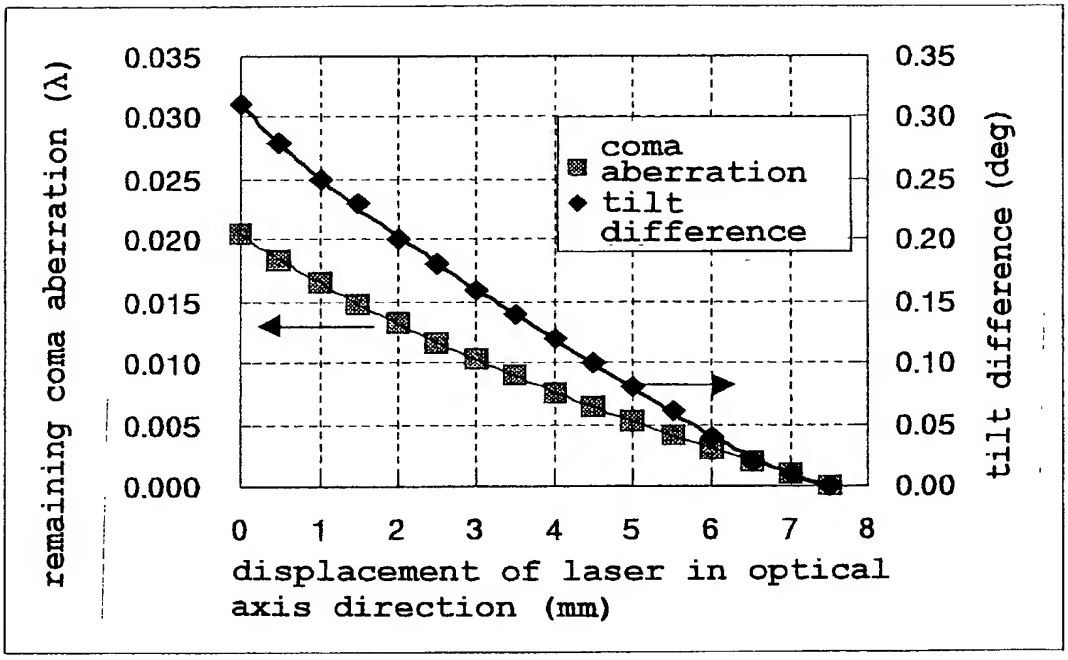

remaining coma aberration (λ)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
tilt difference (deg)
coma aberration
tilt difference
0 1 2 3 4 5 6 7 8
displacement of laser in optical axis direction (mm)

Fig. 4

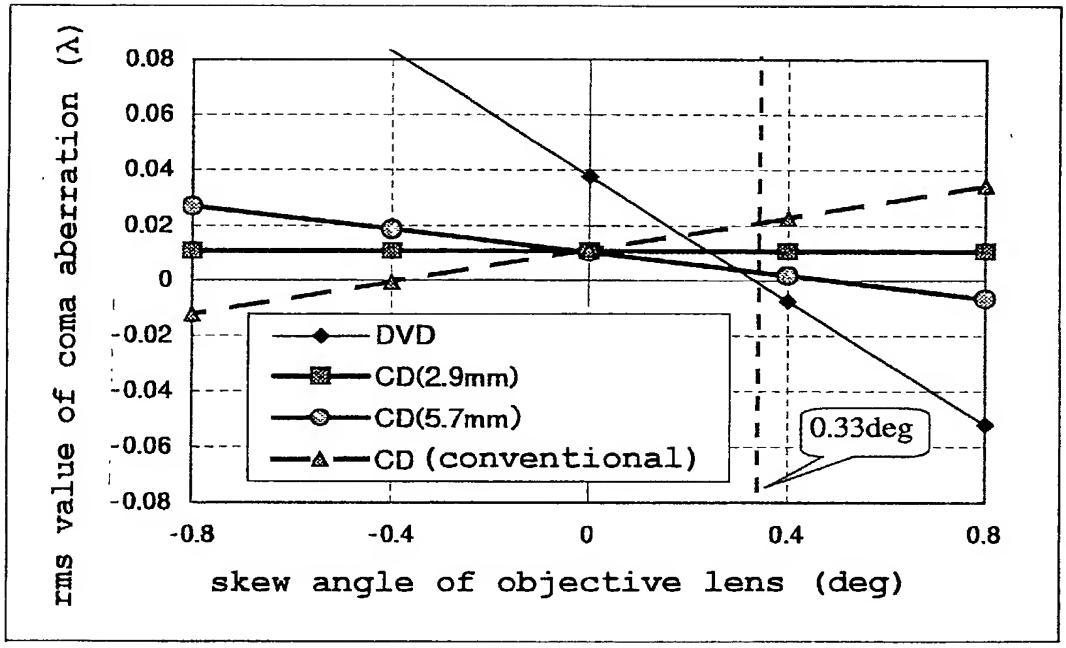
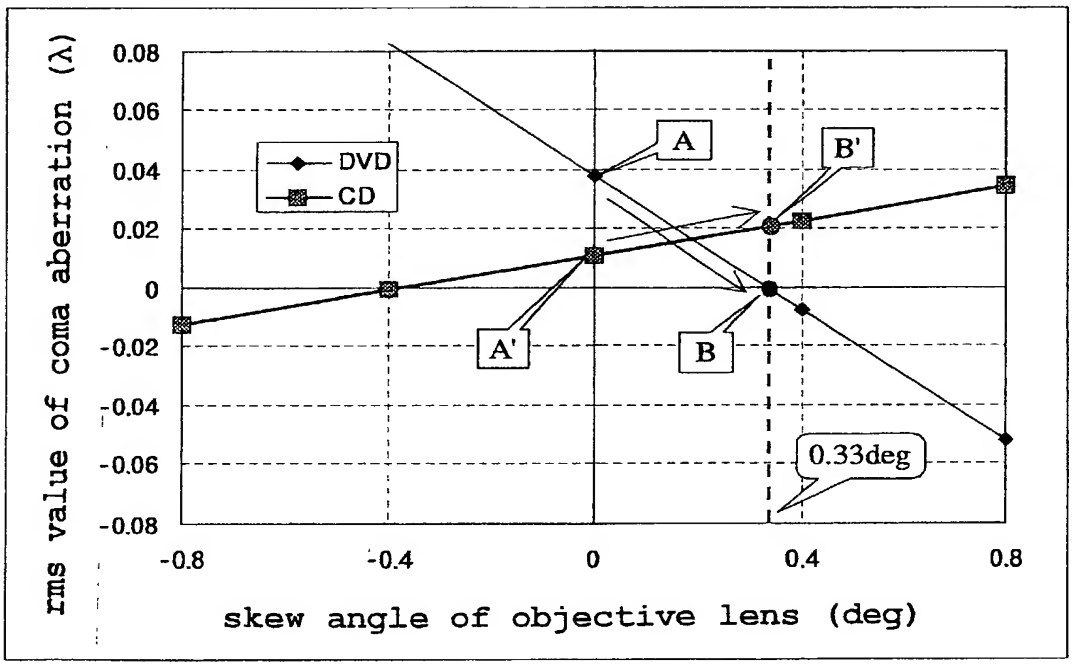

rms value of coma aberration (λ)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.8
-0.4
0
0.4
0.8
skew angle of objective lens (deg)
DVD
CD(2.9mm)
CD(5.7mm)
CD (conventional)
0.33deg

Fig. 5


rms value of coma aberration (λ)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
DVD
CD
A
B'
A'
B
0.33deg
-0.8
-0.4
0
0.4
0.8
skew angle of objective lens (deg)

Declaration and Power of Attorney For Patent Application
English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled Optical Head ,

_____,

the specification of which is attached hereto unless the following box is checked:

☒ was filed on 10 May 2000 as

United States Application Number or PCT International Application Number PCT/JP00/02968

and was amended on November 13, 2001 by Preliminary Amendment (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. §119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Not Claimed
H11-129,601	JAPAN	May 11, 1999	☐
(Number)	(Country)	(Day/Month/Year Filed)	
_____	_____	_____	☐
(Number)	(Country)	(Day/Month/Year Filed)	

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below.

_____	_____
(Application Number)	(Filing Date)
_____	_____
(Application Number)	(Filing Date)

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Number)	(Filing Date)	(Status - patented, pending, abandoned)
(Application Number)	(Filing Date)	(Status - patented, pending, abandoned)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Fourth inventor's signature ____ Date ____

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Citizenship ____

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Fifth inventor's signature ____ Date ____

Residence ____

Citizenship ____

Post Office Address ____

Full name of sixth joint inventor, if any (given name, family name) ____

Sixth inventor's signature ____ Date ____

Residence ____

Citizenship ____

Post Office Address ____

Full name of seventh joint inventor, if any (given name, family name) ____

Seventh inventor's signature ____ Date ____

Residence ____

Citizenship ____

Post Office Address ____